CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN McLEISH, DIRECTOR

Bituminous Sands of Northern Alberta

By

Sidney C. Ells

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1924

Price, 25 cents.

No. 625

Frontispiece. PLATE I.

Bituminous sand pavement laid in Edmonton, Alberta., under supervision of S. C. Ells, Mines Branch, August, 1915.

Canada. Mines, Bureau of-

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BITUMINOUS SANDS OF NORTHERN ALBERTA

INTRODUCTORY

The "Preliminary Report on the Bituminous Sands of Northern Alberta," No. 281, was issued by the Department of Mines in 1914. This report was based on observations made in 1913, during a period of eight weeks' field work. The edition was exhausted some years ago. Subsequent and more detailed field work has adduced much additional information regarding the Alberta deposits. It has not, however, necessitated any change in the views expressed or conclusions arrived at in the original report.

Work undertaken by the Mines Branch, Department of Mines, has included topographic surveys of extensive areas, examination and sampling of the principal outcrops, the mining of trial shipments, laying of demonstration pavements, and a study of methods adapted to the recovery of bitumen from the crude bituminous sand.

GENERAL DESCRIPTION OF AREA UNDERLAID BY BITUMINOUS SAND

The Athabaska and Clearwater valleys constitute the chief topographical features of this area. The principal tributary streams include Christina, Hangingstone and Horse rivers, Poplar creek, Steepbank, Beaver, Muskeg, McKay, Ells (formerly Moose), and Tar rivers, Wolf creek, Calumet and Firebag rivers. Along each of these streams, valley walls are abrupt and the zones in which drainage is effective are as a rule limited in extent. Throughout these narrow zones there is in most places a fair growth of poplar, jack pine or spruce, although a considerable percentage of such growth has been destroyed by fire, and large areas at a distance from the principal valleys are now almost covered by dense second growth poplar and jack pine.

On leaving the valleys, elevations gradually increase. Toward the east, large areas of country are covered by sand. In passing westward, the sand gradually disappears and clay soil becomes predominant.

In the following table an attempt has been made to classify, provisionally, the soil and forest growth. This classification is based on notes made on some 3,000 miles of traverse lines. In many instances it has been difficult to differentiate poplar, spruce and jack pine areas, since this growth is frequently intermixed. Spruce is usually found on bottom lands, along the smaller valleys and in certain swamps. Owing to the irregular nature of such areas, it has been difficult to estimate definitely the total acreage of this growth.

Although the total acreage of merchantable timber constitutes a considerable area, stands of poplar, spruce and jack pine are, as a rule, scattered and, individually, of limited extent. A somewhat extensive area of jack pine in townships 96 and 97, ranges 10 and 11, east of the

Athabaska river, constitutes a notable exception. It is also unfortunate that many areas of clay soil are marked by the presence of numerous irregular muskegs and swamps.

		Character of Forest Growth					Character of Soil			
——		Muskeg slough and swamp	Poplar	Spruce	Jack pine	Second growth (brule)	Clay soil	Sandy soil	River bottom lands	Water area
Tp.	Range	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
88 —	8	35·2	6·7	3·5	....	44·7	40·0	60·0	10·3	2·5
	9	30·2	11·5	11·7	....	37·5	89·9	10·1	....	0·8
	10	31·0	17·7	19·8	....	39·5	95·0	5·0	....	5·0
89—	S. 2/3 8	40·7	15·9	11·1	6·9	24·4	19·5	80·5	1·0	0·2
	9	19·0	36·3	13·1	....	27·6	84·2	15·5	4·0	10·4
	10	38·5	21·2	11·4	....	28·6	67·5	32·5	0·3	2·5
90—	9	37·4	20·8	13·5	....	17·9	25·8	74·2	10·4	7·2
	10	22·2	38·1	17·3	....	22·4	80·0	20·0	....	....
91—	9	48·4	12·2	13·2	....	19·8	30·0	70·0	6·4	7·7
	10	38·9	10·6	21·6	....	28·9	60·0	40·0	....	....
92—	9	48·7	13·7	7·9	7·8	19·9	20·0	80·0	2·0	5·4
	10	52·0	13·9	15·7	....	17·4	20·0	80·0	1·0	4·9
	E. 1/3, 11	49·9	16·9	13·0	....	20·2	40·0	60·0	....	....
93—	9	59·6	5·6	4·3	....	40·5	19·3	80·7	....	....
	10	47·8	9·9	0·8	13·7	15·8	19·7	80·3	11·3	10·1
	E. 1/3, 11	28·0	12·1	0·7	24·7	34·5	....	100·0	....	1·0
84—	9	57·0	9·3	12·8	....	20·9	20·0	80·0	....	2·7
	10	41·9	19·4	11·4	....	23·0	30·0	70·0	0·2	4·2
95—	10	55·5	5·1	6·9	....	30·7	....	100·0	4·2	1·8
	11	47·6	11·7	10·1	0·3	28·5	16·0	84·0	1·8	7·6
96—	10	34·9	6·9	3·2	2·9	32·2	0·9	99·1	....	0·1
	11	48·0	15·2	16·3	10·4	18·4	2·8	97·2	0·6	8·8
97—	10	27·9	5·7	....	12·6	53·6	1·0	99·0	0·2	2·2
	11	42·6	16·7	3·3	16·4	20·4	1·0	99·0	0·6	6·1
98—	9	3·4	....	....	2·2	94·4	....	100·0	....	11·1
	10	31·2	3·9	0·4	8·4	55·4	....	100·0	0·7	8·2
	11	48·6	1·4	....	2·4	48·6	2·8	97·2	....	....
99—	8	....	....	....	0·4	99·2	....	100·0	0·1	0·3
	9	36·9	3·5	....	8·6	49·7	....	100·0	1·3	4·6
	10	44·0	6·1	....	7·2	40·4	....	100·0	2·3	6·3
100—	8	11·2	1·5	0·8	0·8	82·6	0·4	99·6	....	1·5
	9	16·4	8·9	8·0	8·5	36·6	5·0	95·0	21·6	8·8
	10	61·2	6·5	....	15·5	16·8	1·5	98·5	....	....

GENERAL DESCRIPTION OF DEPOSIT

Extent of Deposit.—It is at present impossible to attempt an accurate estimate of the area underlain by bituminous sand. The writer has examined upwards of 270 individual outcrops, all of which represent parts of an almost continuous deposit. These outcrops occur at intervals along the Athabaska river and its principal tributaries, for a total distance of more than 220 miles. On the Athabaska river, the most northerly exposure of apparent commercial importance occurs in sec. 16, tp. 98, range 10. Other minor exposures are, however, seen along the Athabaska as far as the northern boundary of township 105. The direct distance in a north and south direction through which outcrops have been noted is approximately 115 miles, and that from east to west approximately 45 miles. Extensions of the deposit under heavy overburden, particularly toward the south, will materially increase the above estimate. Having

due regard to methods at present practicable for mining bituminous sand, and considering other controlling factors such as variation in quality, the area actually available for commercial development at present, probably does not exceed one per cent of the above estimate. In addition to the occurrences indicated other exposures of bituminous sand have been found at points many miles to the east and west, notably on the Wabiskaw river, on the headwaters of Tar river, on Muskeg river, on Buckton creek, and on Firebag river, Alberta; and on Buffalo lake, Saskatchewan. Certain of these exposures have been examined by the writer; but if commercial development of the various outcrops in the McMurray district is found to be impracticable, it is evident that deposits in the outlying areas noted above cannot be considered as of present economic importance.

In view of the above it will be seen that, in considering possible commercial development of bituminous sand areas, the thickness of overburden and the ground available for the disposal thereof, freedom from impure partings, uniformity and degree of enrichment, and conditions affecting transportation, may be recognized as among the principal controlling physical factors. Other factors, such as fuel supply, labour, etc., will not be discussed here.

Variation in Character of Material.—In many cases it has been possible to eliminate definitely certain parts of the area from further consideration, as regards their economic importance; but for reasons noted elsewhere, it is not at present an easy matter to designate definitely those areas that may prove of greatest commercial value. Mere measurements of what are in many cases imperfectly exposed vertical sections cannot convey much information. At different points, wide variation occurs in the quality of the material, the thickness and character of the overburden, and in those topographical and geographical conditions which must, to a large extent, control possible future development. Indeed, only after detailed exploration by means of adequate equipment can the true value of any area be definitely determined.

Variation in Grading of Mineral Aggregate.—For certain purposes too much importance cannot be attached to the desirability of securing a product of uniform grade. It would seem that, apart from considerations of transportation, this feature probably more than any other has, in the past, discouraged the development of many deposits of bituminous sand in the United States. In a body of siliceous sand of such wide areal extent as that under consideration, wide variation in the grade and purity of the mineral aggregate must be expected and does exist. However, this is true even within very narrow limits in the McMurray district. In a number of cases where the original grading of the mineral aggregate is not satisfactory, a desired grading may be obtained by a combination of the bituminous sand from two, or even three outcrops. To effect such a combination commercially does not imply undue difficulty.

Variation in Bituminous Content.—To some extent, the degree of impregnation has depended on the grading of the sand. The medium-grained and moderately compact deposit is as a rule the richest, whereas

the finest aggregates have apparently retarded complete saturation. Thus the percentage of associated bitumen varies widely in all exposed sections examined.

Impure Partings.—Throughout the majority of the exposed sections examined, impure partings occur to some extent. In the majority of instances these partings, being impervious, act as sills along which the bitumen from overlying sands is concentrated.

Having in view considerations such as the above, the desirability of securing accurate samples by the systematic boring of any area selected for commercial development becomes obvious.

To some extent, the percentage of contained bitumen, and the prevalence of impure partings, may be recognized in the appearance of an exposed section. Beds of high-grade, homogeneous, bituminous sand are usually marked by a typical conchoidal cleavage roughly parallel to the face. Such cleavage or flaking off is especially noticeable where heavy overburden has set up transverse pressure. Where the percentage of contained bitumen is low, the cleavage becomes more angular.

In the study of petroleum fields, an appreciation of the probable genesis of petroleum is obviously of practical importance. No less important is a study of conditions that have resulted in the formation of the Alberta deposits of bituminous sands, and of the origin of the associated bitumen. This feature will be more fully discussed in a complete report now in course of preparation.

For many years, the occurence of so called "tar springs" or seepages of bitumen has been recognized throughout the area under discussion. The writer is familiar with upwards of 40 such springs, but in no instance are they in themselves of commercial value as a source of bitumen. They have, at times, been regarded erroneously as a definite indication of the presence of petroleum pools. Instead of coming from below, however, the bitumen merely seeps laterally from slightly inclined beds of particularly rich, coarse-grained sand. An underlying impervious clay parting, together with a small local depression, makes possible the formation of a small pool of bitumen.

It is noticeable that in general, the lower portions of the deposit consist of unstratified sands, and prior to impregnation, these sands were apparently uncompacted. Consequently, these lower portions are usually of a fairly homogeneous character. In passing upward, however, narrow bands of sandstone, clay, lignite, and quartzite are found interbedded. These unimpregnated strata gradually increase in number until they may in places almost entirely replace the bituminous sand.

Thickness and Character of Overburden.—In the Athabaska valley and along the principal tributary streams, areas may be subdivided into two general groups. (Plates II and III.)

Plate II.

Outcrop bituminous sand on Athabaska river (Sec. 2, Tp. 89, R. 10)

Plate III.

Outcrop bituminous sand on Athabaska river (Sec. 24, Tp. 95, R. 11)

Plate IV.

Outcrop bituminous sand on Horse river, Alberta (Sec. 8, Tp. 89, R. 9)

(i) Low lying areas represented by outcrops that rise to a height of 5 to 30 feet, immediately along the present stream channel. These outcrops represent such small residual areas of bituminous sand as still remain in the original valley bottom, and have a comparatively light overburden. (Plate IV.)

(ii) Exposures where streams have impinged against the sides of the main valley. Such exposures, in general, show a thick section of bituminous sand, and also a heavy overburden. Topographical maps, in preparation illustrate those areas where overburden is either very heavy or comparatively light. Such maps, however, must eventually be supplemented by systematic core-drilling.

As might be expected in a country covered by a heavy mantle of clay, in which streams are deeply entrenched, slips in the bank constitute a notable feature. Individual slides at times bring down many thousands of tons of clay and soil.

In passing northward, elevations and consequently depths of overburden throughout the zone drained by the Athabaska river gradually decrease.

Sections of many of the more important outcrops have been measured. In doing this an attempt was made to determine the thickness of bituminous sand of commercial grade, the thickness of what may be referred to as low grade material, and of which probably the greater part must be classed as overburden, and finally the probable thickness and character of surface drift and other overburden. In many instances earth slides, the encroachment of the timber line along the upper part of an exposure, and a talus piles along its foot, have partly obscured the outcrop. In such cases, the securing of accurate measurements would have necessitated extensive excavation work, and approximations were therefore made. For similar reasons it was found somewhat difficult to accurately indicate the length of many of the outcrops. Such data, even if available, would frequently have little significance, since the numerous outcrops merely represent small portions of a continuous deposit. It is quite possible that certain parts of the deposit, which are at present partly or wholly obscured by timber or drift, may, on examination, prove to be more advantageously situated for development purposes than are many of the sections that happen to be so well exposed at present.

A brief reference to the geological section along the Athabaska river will furnish some indication of the general character of the overburden. Between Athabaska and the Cascade rapids, La Biche shales, Pelican sandstones and shales, Grand Rapids sandstones and Clearwater shales are, at various points, well exposed; but northward and eastward from the Cascades rapids, the Clearwater series and surface drift appear to constitute the entire overburden above the bituminous sand. Thus, in undertaking stripping operations, the class of material to be excavated should present no serious difficulty, since shales and soft sandstones, with occasional thin bedded quartzites, apparently represent the bulk of the strata to be removed. The surface drift consists chiefly of boulder clays and sand. Other conditions being equal, areas lying within triangles at the junction of two streams present decided advantages from the standpoint of the removal and disposal of overburden.

PROSPECTING

The method adopted in prospecting any bituminous sand area will depend on the thickness and character of the material overlying the bituminous sand, and on the accessibility of the area by water or pack trail transportation. Where the thickness of overburden does not exceed 30 feet, test pits may be sunk to the bituminous sand, and core samples then secured by means of asphalt augers. Where the overburden exceeds 30 feet in thickness, core drilling by means of light power drills will be found more efficient. Trenching above outcropping bituminous sand rarely gives satisfactory information of the thickness and character of the overburden.

In preparing final estimates of the quantities of overburden and of bituminous sand, accurate detailed mapping is essential. In the type of ground under consideration, the writer has found that maps showing contours drawn at intervals of five feet and plotted to a scale of one inch equal to 200 feet, are satisfactory.

Conditions met with in the Horse River reserve (secs. 5 and 8, tp. 89, range 9, W. of the 4th mer.) may be considered as characteristic of a large area lying south of township 96. As an indication of the importance attached to the removal and disposal of overburden, it may be stated that, on the Horse River reserve, the estimated overburden amounted to approximately 3,180,000 cubic yards. The removal of this overburden would make available approximately 3,360,000 tons of bituminous sand.

SAMPLING AND LABORATORY DETERMINATIONS*

As already noted, the percentage content of bitumen varies widely, but analyses included in the following table are considered as representative of a large number of areas. Other analyses, not quoted, have shown a bitumen content of from 20 to 25 per cent, but these are not considered as representative of any large tonnage. Nearly all samples were secured by core drilling of outcrops.

*All analyses and determinations by the writer.

Abridged Analyses of Samples of Bituminous Sand from the McMurray District

Test No.	Source	Passing Mesh 200	100	80	50	40	30	20	10	Per cent contained bitumen
11	Athabaska river	2	11	54	16	10	5	2	....	14
12	"	6	54	25	13	....	....	....	....	15
12	"	7	77	14	2	....	....	....	....	16
15	"	24	64	9	3	....	....	....	....	17
15	"	3	38	19	40	....	....	....	....	9
16	"	9	33	11	47	....	....	....	....	12
21	"	3	5	1	8	7	15	33	27	15
21	"	4	26	11	48	3	2	3	3	20
22	"	11	70	14	5	....	....	....	....	12
47	Christina river	3	6	8	12	14	45	12	....	11
49	"	3	15	11	70	1	....	....	....	14
52	"	2	35	12	51	....	....	....	....	17
52	"	4	34	16	46	....	....	....	....	15
39	Clearwater river	4	14	14	48	9	7	4	....	14
43	Hangingstone creek	3	22	9	51	9	4	2	....	15
31	Horse creek	5	38	8	47	2	....	....	....	16
32	"	5	47	16	32	....	....	....	....	16
33	"	5	36	14	45	....	....	....	....	15
34	"	10	33	19	37	1	....	....	....	17
35	"	4	27	11	56	2	....	....	....	9
35	"	7	77	5	11	....	....	....	....	17
36	"	4	40	5	51	....	....	....	....	16
36	"	5	39	27	29	....	....	....	....	11
37	"	3	35	15	57	....	....	....	....	18
38	"	5	42	18	35	....	....	....	....	11
38	"	4	30	18	47	1	....	....	....	16
73	McKay river	2	49	26	22	....	....	....	....	16
74	"	6	25	16	40	4	9	....	....	18
64	Ells river	6	75	18	1	....	....	....	....	15
67	"	8	53	19	20	....	....	....	....	16
63	Muskeg river	7	10	1	27	20	16	10	6	9
54	Steepbank river	3	8	2	25	16	20	15	9	14
55	"	7	4	1	12	10	17	27	22	16
56	"	2	4	1	42	22	13	9	4	17
58	"	5	33	2	43	7	4	2	3	16
59	"	3	14	2	72	5	5	1	....	16
61	"	7	10	1	27	20	16	10	6	8

The physical characteristics of a representative sample of the bituminous sand, and of the bitumen itself, may be briefly summarized thus:—

Crude bituminous sand—*

Specific gravity 25° C/25° C	1·75
Moisture	1·3%
Bitumen soluble in CS_2	18·5%
Sand	80·2

CHARACTERISTICS OF SAND

The sand consists, for the most part, of clear quartz grains. In form the grains are most irregular, varying from sharply angular to oval, water-worn shapes. Judging from the grading of the sand, the bulk of which ranges from 40 to 80 mesh, the greater part may be considered as originating as shore deposits.

*The table on page 15 indicates the tonnage of bituminous sand for various areas and thicknesses. Specific gravity of bituminous sand taken as 1·75. Short tons of 2,000 pounds.

The following is an analysis of sand combined from samples taken from six representative outcrops:—

	Per cent
SiO_2	95·50
Al_2O_3	2·25
CaO	0·50
Fe_2O_3	0·35
MgO	0·23
Less loss on ignition	1·50
Total	100·33

CHARACTERISTICS OF SEPARATED BITUMEN **

Specific gravity, 25° C/25° C	1·018
Fixed carbon	7·23%
Sulphur	4·85%
Bitumen soluble in 76° naphtha	82·8 %
Bitumen soluble in 88° naphtha	78·2 %
Carbenes	trace
Ash***	trace
Saturated compounds in 88° naphtha solution	39·6 %
Unsaturated compounds in 88° naphtha solution	60·4 %
Stickiness	4,881·0 %
Penetration at 115° F	too soft
Penetration at 77° F.—	
(100 grams. 5 sec.)	too soft
(100 grams. 1 sec.)	9·0 mm.
Penetration at 32° F.—	
(100 grams. 5 sec.)	2·5 mm.
Ductility at 77° F	100 cm.+
Volatile 160° C.—5 hours (Using New York testing oven)	11·2 %
Volatile 205° C.—5 hours (Using New York testing oven)	14·2 %
Volatile 250° C.—4 hours (Using New York testing oven)	18·8 %

CHARACTERISTICS OF RESIDUAL BITUMEN AFTER HEATING

	165° C. 5 hours	205° C. 5 hours	250° C. 4 hours
Specific gravity, 25° C/25° C	1·021	10·77 %	1·028
Fixed carbon	8·99%	none	12·33%
Sulphur	none	trace	none
Carbenes	trace	114° F.	trace
Fusing temperature	106° F.	too soft	125° F.
Penetration at 115° F	too soft	1·025	too soft
Penetration at 77° F.—			
(100 grams, 5 sec.)	26·2 mm.	12·2 mm.	5·8 mm.
Penetration at 32° F.—			
(200 grams, 1 minute)	10·5 mm.	5·3 mm.	2·4 mm.
Ductility at 115° F	100 cm.+	100 cm.+	34·5 cm.
Ductility at 77° F	100 cm.+	99 cm.+	45·0 cm.
Tensile strength at 115° F			0·3 Kgs.
Tensile strength at 77° F			1·5 Kgs.
Tensile strength at 32° F			25·5 Kgs.

**All extractions by use of CS_2.
***Fine mineral matter not removed by extraction.

TONNAGE OF BITUMINOUS SANDS FOR VARIOUS AREAS AND THICKNESSES

Thickness in feet	Tons on 1 acre	Tons on 2 acres	Tons on 3 acres	Tons on 4 acres	Tons on 5 acres
1	2,380	4,800	7,100	9,500	11,900
5	11,900	23,800	35,800	47,700	59,600
10	23,800	47,700	71,600	95,400	119,200
15	35,800	71,600	107,300	143,100	178,905
20	47,700	95,400	143,100	190,800	238,500
25	59,600	119,300	178,900	238,500	298,200
30	71,600	143,100	214,600	286,200	357,700
35	83,500	166,900	250,400	333,900	417,400
40	95,400	190,800	286,200	381,600	477,000
45	107,300	214,600	321,900	429,300	536,600
50	119,200	238,500	357,700	477,000	596,300

FUEL AND POWER IN THE McMURRAY DISTRICT

Four possible sources of fuel supply may be briefly referred to:—

(*a*) *Seams of Lignite Coal.*—The writer has sampled a number of seams of lignite coal on Athabaska, McKay and Christina rivers. Analyses of these samples appear to indicate that, although in places the coal is of good quality, in general the seams occur as local lenses associated with the bituminous sand, and that they are of very doubtful commercial value.

(*b*) *Natural Gas.*—Gas sands have a wide distribution in northern Alberta. At present the producing wells nearest to McMurray are those at Lower Pelican. These wells have an estimated capacity of about 750,000 cubic feet per 24 hours, and are distant from McMurray approximately 90 miles in a direct line. At the mouth of Little Buffalo river, 50 miles from McMurray in a direct line, there is a strong seepage of natural gas. No development work has been attempted at this point, nor is anything known regarding the character of the gas itself. The writer considers that intelligent prospecting for natural gas, at points a few miles south of McMurray, would have a reasonable chance of meeting with success. A well sunk some years ago by A. von Hammerstein, near Tar island (sec. 18, tp. 92, range 9, W. of the 4th mer.), approximately 20 miles north of McMurray, gave a small flow of gas. More recently (1916) some gas was struck at a depth of 323 feet in a well drilled in tp. 87, range 7, W. of the 4th mer., and a small flow was also met with at a depth of 1,145 feet in a well located in sec. 26, tp. 83, range 6, W. of the 4th mer.

(*c*) *Lignite Coal (from points outside the McMurray district).*—Coal produced in the Edmonton district has an average heating value of about 9,000 B.Th.U. The rail haul to McMurray would be approximately 300 miles.

(*d*) *Crude Bituminous Sand.*—The writer has submitted the question of burning crude bituminous sand under boilers, to a number of makers of mechanical stokers. Reports on the material, although not conclusive, appear to indicate that the successful utilization of such a material in this manner is extremely doubtful. The use of gas producers has been suggested. One pound of 14 per cent bituminous sand contains 2,240 B.Th.U. of potential heat.

(e) Potential Water Powers Tributary to McMurray.—Information relative to water powers at Grand rapids on the Athabaska river, and at Whitemud rapids, Aux Pins rapids, and Cascade rapids on the Clearwater river, has been secured by the Water Powers Branch of the Department of Interior, Ottawa. From data available, it appears that conditions for power development at these points cannot be considered as favourable at present.

TRANSPORTATION

A standard gauge railway, known as the Alberta and Great Waterways, has been constructed from Edmonton to Waterways, Alberta, at the head of navigation on the Athabaska-MacKenzie system, a distance of approximately 290 miles. The grade has been completed six miles farther, to McMurray settlement.

As yet no steps have been taken to provide adequate transportation between McMurray and certain promising areas in townships 94, 95, 96 and 97. The logical location of a railway northward from McMurray, appears to be along the river bottom lands to the west of the Athabaska river. Apart from the river crossing near McMurray, no serious engineering difficulties would be encountered. Such an extension of the Alberta and Great Waterways railway would serve the Beaver river, McKay river, and Ells River areas. Connection with certain promising areas lying to the east of the Athabaska—as on Steepbank river, and in townships 95, 96 and 97—could doubtless be arranged.

The Athabaska river, between McMurray and Fort McKay, affords a minimum draft of 2 feet 6 inches during at least four months of the year. It is believed that during the period of open navigation, specially designed towing boats and scows could be operated at a reasonable cost.

WEATHER CONDITIONS IN THE McMURRAY DISTRICT

The climate in the McMurray district during the spring, summer, and autumn, is not unlike that of central Alberta. Winter weather is dry and healthful and very similar to that which prevails in the Cobalt and Porcupine mining districts of northern Ontario. The snowfall is light.

Reliable meteorological records have been kept at McMurray since 1916. These include daily readings of maximum and minimum temperatures for morning and afternoon, and also precipitation throughout the year.

The following table has been compiled from records, furnished by Mr. Cyril Potts, J.P., Crown Lands Agent and Meteorologist, McMurray, Alberta:—

Meteorological Record of the McMurray District, Alberta, 1916-19

—	1916	1917	1918	1919
Mean maximum temperature—				
January	−14·1	− 3·1	− 2·2	19·6
February	18·2	4·1	....	9·9
March	20·6	29·3	....	20·7
October	44·4	42·9	....	34·9
November	28·4	39·9	....	17·7
December	9·5	−10·7	17·8	6·8
Mean minimum temperature—				
January	−31·7	−24·1	−23·9	−5·5
February	−12·6	−24·4	−21·1	−16·8
March	− 9·1	− 1·1	− 1·7	−12·0
October	26·5	22·4	....	12·4
November	18·1	19·9	....	− 1·8
December	−11·3	−31·8	− 6·2	−15·4

COMMERCIAL APPLICATION OF BITUMINOUS SAND

PAVING CONSTRUCTION

Following a preliminary examination of the deposits of bituminous sand undertaken in 1913, the writer suggested that a section of experimental pavement be laid. It was felt that such a pavement would illustrate in a practical manner, the value of the Alberta deposit as a possible source of paving material. During 1914, a quantity of the bituminous sand was shipped to Edmonton, and laid as a pavement. This pavement comprised sections of three types of surfacing, viz., sheet asphalt, bitulithic and bituminous concrete, and was opened to traffic on August 26, 1915. In October, 1923, the pavement was still in first-class condition, and had required no repairs.

As a site for this pavement, a section of Kinnaird street immediately south of Alberta avenue was selected. The traffic along this part of Kinnaird street may be classed as heavy, and the pavement has, therefore, been given a fairly severe test, for in addition to a large amount of automobile travel, traffic includes vehicles that carry loads up to eight and ten tons.

The principal arguments advanced against the use of crude bituminous sands as a paving material are:—

(a) Unbalanced mineral aggregate.

(b) Lack of uniformity.

(c) Freight charges.

In the past, consideration of the merits of bituminous sand has been based largely on the assumption that mixes in which it may be incorporated must conform to present recognized standard paving specifications. In the opinion of the writer, an attempt should be made rather to design a mix in which the admittedly valuable inherent merits of the material

will be utilized to the greatest advantage. At present it is not definitely known whether a large tonnage of uniformly graded bituminous sand is available, but in the writer's opinion, areas may be found where such conditions exist.

Until a decision is reached regarding freight rates on bituminous sand from Waterways to Edmonton and other distribution centres, it will be impossible to indicate definitely the radius within which competition with imported oil asphalt will be possible. The following estimate based on present (1924) costs of materials in Edmonton, Alberta, furnishes a general comparison between bituminous sand mixes and mixes in which clean sand, crushed gravel and imported bitumen (oil asphalt) are used. The estimated value of bituminous sand is deduced by subtracting the total value of other ingredients from the cost of one ton of mixture, consisting of imported oil asphalt, combined with local sand and crushed rock.

Tabulation of the Costs of Material for Bituminous Mixture. Based on 1924 prices delivered at the Plant.

SAND AND ROCK MIXTURES WITH IMPORTED ASPHALT

—	Bituminous sand	Clean sand at $1.44 per ton	Filler Portland cement at $20 per ton	Crushed gravel at $2.40 per ton	Asphaltic cement at $30 per ton	Total cost of material per ton of mixture
Sheet asphalt	....	82 p.c. $1 18	7 p.c. $1 40	....	11 p.c. $3 30	.... $5 88
Bituminous concrete	....	46 p.c. $0 66	4 p.c. $0 80	42 p.c. $1 01	8 p.c. $2 40	.... $4 87
Bitulithic	....	32 p.c. $0 46	4 p.c. $0 80	56 p.c. $1 34	8 p.c. $2 40	.... $5 00

BITUMINOUS SAND MIXTURES

—	Bituminous sand	Clean sand	Filler Portland cement	Crushed gravel	Asphaltic cement	Total
Sheet asphalt	79 p.c. $5 37 $4 24	13·8 p.c. $0 20	7·2 p.c. $1 44	....	....	.... $5 88
Bituminous concrete	58 p.c. $6 73 $3 90	4 p.c. $0 06	....	38 p.c. $0 91	....	.... $4 87
Bitulithic	52·5 p.c. $6 74 $3 54	1·9 p.c. $0 03	1·9 p.c. $0 38	43·8 p.c. $1 05	....	.... $5 00

In certain parts of the United States, bituminous sands and sandstones and bituminous limestones have been used to some extent as a surfacing material for city streets and country highways.

California.—During the interval between 1890 and 1916, the City Street Improvement Company operated a bituminous sand quarry near Godola, California, (Plate V), the material being used to some extent in the surfacing of highways and city streets. Until 1910 operations by the company had been marked by many failures, due to faulty methods in the manipulation of the bituminous sand. In 1910, Mr. J. R. Price took charge of paving operations for the company and, by introducing new

methods, was entirely successful in demonstrating the merits of the bituminous sand. This statement is borne out by letters from Walter N. Frickstad, Superintendent of Streets, Oakland, Cal.; M. M. O'Shaughnessy, City Engineer, San Francisco, Cal.; Eldon A. Garland, City Engineer, Santa Barbara, Cal.; and is confirmed by the writer's own observation.

In 1913, in competition with oil asphalt (residuum) at $9 per ton, the product from the above quarry was shipped by rail to many points in California, the maximum rail haul being about 200 miles. Where contract specifications permitted the optional use of bituminous sand or of oil asphalt mixes the City Street Improvement Company used bituminous sand.

At a number of points in northern Alberta, bituminous sand may be quarried under more favourable conditions than those that prevail at Godola.

Oklahoma and Texas.—During the past thirty years, James S. Downard and his associates have constructed upwards of 100 miles of wearing surface in which bituminous sand, bituminous limestone or a mixture of the two has been used successfully. In competition with $20 oil asphalt, the maximum rail haul has exceeded 400 miles.

Since 1911, the Uvalde Rock Asphalt Company, of San Antonio, Texas, has constructed several hundreds of miles of wearing surface on streets and highways, in which a 12 per cent bituminous limestone has been used. It is stated on reliable authority that the use of this material has proved entirely satisfactory. Annual construction during recent years has exceeded 1,000,000 square yards of wearing surface.

Kentucky.—The largest company handling bituminous sand at present is the Kentucky Rock Asphalt Company, operating quarries at Kyrock, Ky. (Plate VI). The thickness of the beds worked varies from 15 to 52 feet, with an average thickness of 25 to 30 feet. The thickness of overburden ranges from 10 to 45 feet, and consists of solid sandstone overlain by 2 to 3 feet of clay. The overburden is blasted down, steam-shovelled, and train-hauled to waste piles. The bituminous sand has an average content of 7 per cent bitumen, and after blasting, is train-hauled to the crushing plant. The present (1924) capacity of the plant is approximately 1,200 tons per day. Apart from the crushing plant, other equipment in use comprises ten steam shovels, five cranes, five derricks, twelve locomotives, and ninety dump cars, the whole representing an investment of upwards of $2,000,000. During 1923, contractors using Kentucky bituminous sand and operating in twenty-six states, laid a total of about two and one-half million yards of pavement.

All bituminous sand shipped by this company is accurately checked by analyses, and the quality of the product is carefully controlled.

A primary object in developing Alberta bituminous sand is to secure a low-priced material suitable for the surfacing of country roads in the provinces of Manitoba, Saskatchewan, and Alberta. An important factor in connection with such construction is the difficulty frequently met of securing local supplies of sand and crushed rock. There is, however, available an abundance of clay and loam. First cost and maintenance

charges must, of course, be low for such a road. If, therefore, we assume commercial production of a fairly pure bitumen from the bituminous sand, the question of incorporating this high-grade material with clay, sand-clay or burnt clay mixes at once becomes of interest. Considerable work has been done on this problem in the University of Alberta, and although it is not the writer's intention to discuss this problem in the present paper, the following brief comment may be made.

During the past fifteen years, numerous attempts have been made in the United States to develop a wearing surface, in which bitumen and carefully prepared burnt clay have been incorporated. Examples of this type of surface may be seen in Scranton, Pa.; Kansas City, and Independence, Mo.; Iola, Kansas; Armourdale, Kansas; and elsewhere. In a majority of cases, the wearing surface has been laid on properly prepared macadam or on a concrete base.

Summarizing the opinion of city engineers and other competent judges with whom the writer has discussed this type of surface, it appears that in general the results have so far not been encouraging. Under climatic and other conditions such as exist in the province of Alberta, it appears doubtful whether clay-bitumen mixes, unless on a permanent base, will prove successful.

BITUMINOUS SAND FOR SIDEWALK CONSTRUCTION

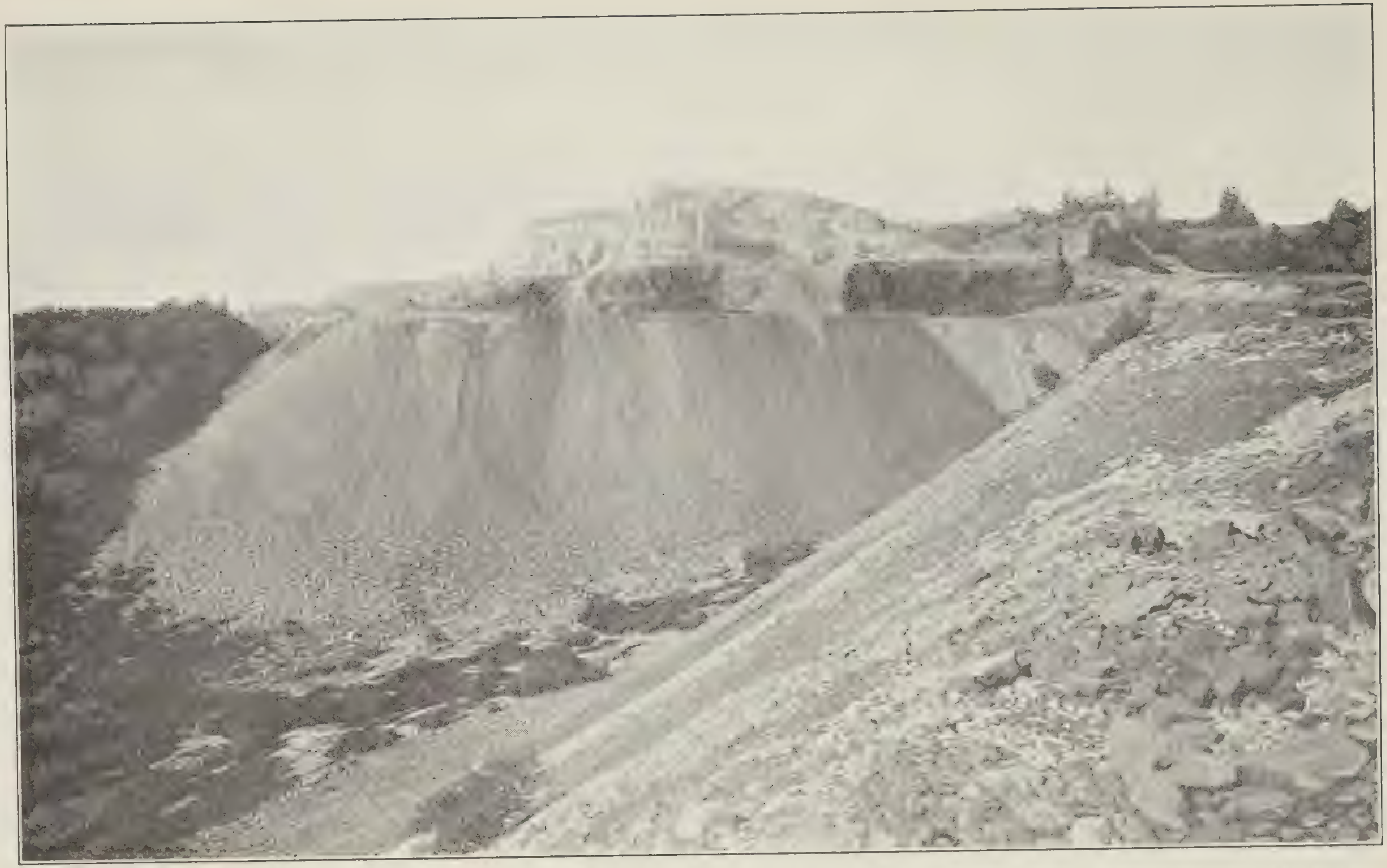
In European cities, bituminous materials have been used extensively for sidewalks for many years. In Paris alone, the length of such walks exceeds 1,800 miles. Such a type of walk is agreeable to the foot, and gives more secure footing than cement or granite flags.

Sidewalks consisting largely of bituminous sand have been constructed to some extent in the United States, and, when properly designed, have given excellent results. In 1915, the writer designed a number of suitable mixes by combining Alberta bituminous sand with varying proportions of clean sand and crushed rock. During the fall of 1922, the city of Edmonton, Alberta, constructed approximately 960 square yards of sidewalk surfacing, using bituminous sand. This work was carried out under the direction of Mr. A. W. Haddow, city engineer, who reports that this surface has proved very satisfactory from the pedestrian's viewpoint.

RECOVERY OF HYDROCARBONS

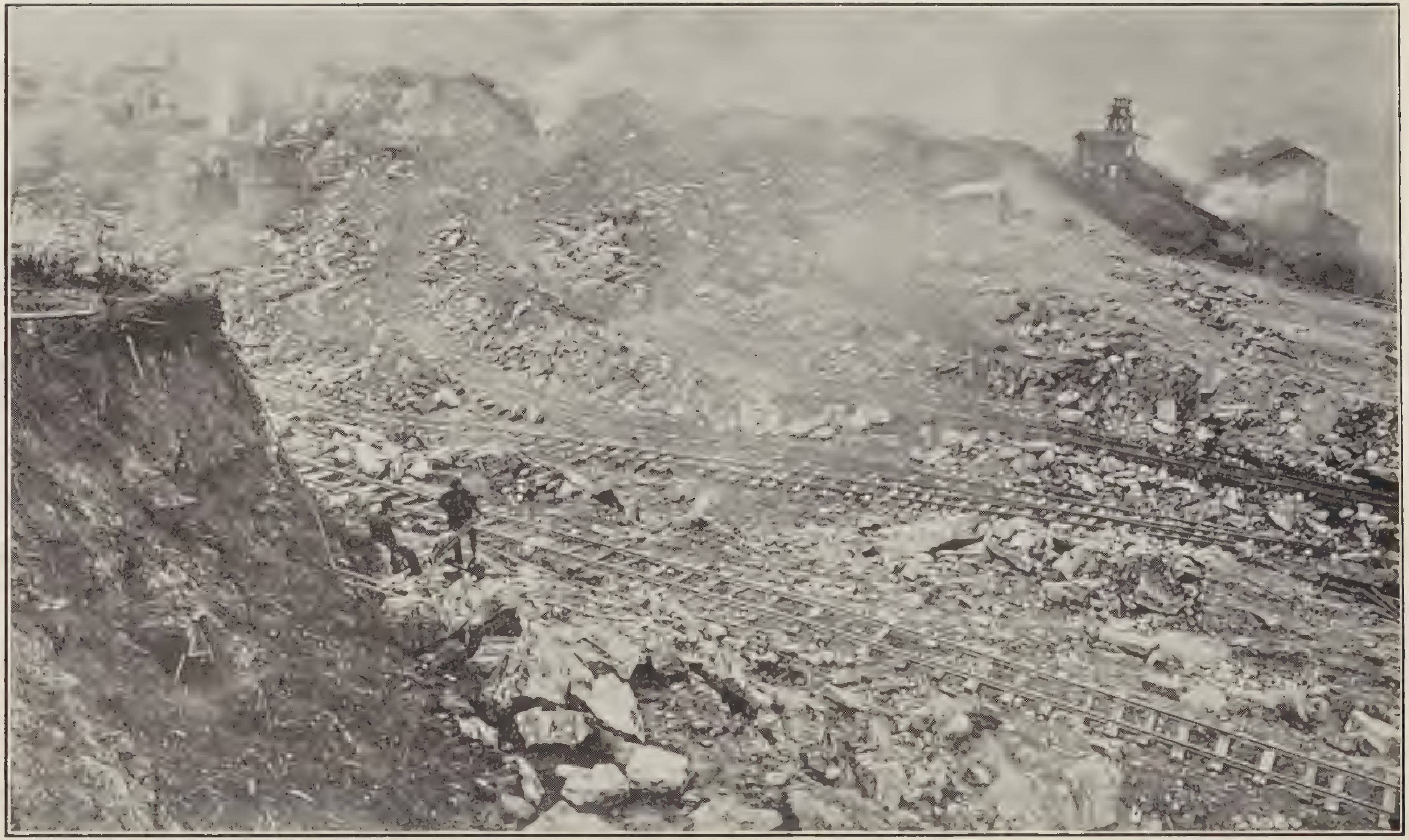
In 1913, the writer indicated that, in any attempt to ship crude bituminous sand, freight charges would handicap seriously any large commercial development in the McMurray district.* This view is now accepted generally and requires no comment. For many years prior to 1913, however, the desirability of developing a successful process for the commercial recovery of the hydrocarbons associated with bituminous sand and bituminous limestone had been recognized in foreign countries, and no little study had been given to the problem. Active interest in the

*On the basis of quantity of imported asphalts entered for consumption in Canada during the fiscal year 1913-14, ten acres of bituminous sand, 50 feet in thickness, would supply the paving requirements of the provinces of Alberta, Saskatchewan and Manitoba, for a period of approximately 24 years.



Bituminous sand quarry, near Godola, Cal. Thickness of 15% bituminous sand 60 feet; thickness of rock overburden 60-70 feet.

Plate VI.



Bituminous sand quarry, operated by Kentucky Rock Asphalt Company, Kyrock, Ky.

matter ceased about the year 1900, owing largely to the rapidly increasing production of well petroleum in the United States, together with a marked modification in oil refinery practice. More recently, changing conditions have appeared to warrant further investigation of the recovery problem.

Prior to 1900, the treatment of bituminous sand and bituminous limestone was directed merely toward the production of a bitumen, little altered from its original consistency. During more recent years, effort has also been directed toward the recovery of the original bitumen, either in the form of crude petroleum or of various petroleum fractions.

AS SEPARATED BITUMEN

At present it appears that the market for solid or semi-solid bitumen in western Canada is limited.* This market should materially expand when various applications for what is admittedly a high grade bitumen become more widely recognized. Among such applications already recognized, and to some extent demonstrated, are its use as asphalt cement in the construction of city streets, highways, and sidewalks; as a binder for briquetting fuels; as a base for paints and varnishes; as an ingredient of roofing preparations; and as a constituent of synthetic mastic, which has a wide application in connection with building construction. Among the many uses to which mastic has been successfully applied, are the construction of various types of flooring (as in public buildings, breweries, courtyards, laboratories, armouries, powder magazines and explosives factories, railway and freight sheds), footways, roofing, damp courses, foundations for high speed machinery, engine beds, and heavy hammers, waterproofing courses for arches of bridges and viaducts, fireproofing, lining of acid-proof tanks, and compressed slabs or blocks.

The probable commercial value of the spent sand, particularly in the manufacture of certain glasses, appears to be slight under present market conditions, and in the face of present competition.

AS CRUDE PETROLEUM

The production of crude petroleum** or petroleum fractions from bituminous sand, is a many-sided question that can merely be touched upon in a brief paper. The importance of such production, if commercially

*Statement showing quantity of undermentioned hydrocarbons entered for consumption in Canada at Winnipeg, Calgary, Edmonton, Regina, Saskatoon, New Westminster, and Vancouver:—

Asphalt, Solid

	1911–12	1912–13	1913–14	1921–22	1922–23
Value.........$	139,586	276,431	127,446	64,506	72,197
Tons..........	7,857	17,814	7,363	....	3,367

Asphalt, not Solid

	1913–14	1921–22	1922–23
Value....................................$	24,412	339	11,336

**Total quantities and value of petroleum products other than solid and semi-solid asphalts entered for consumption in the provinces of Manitoba, Saskatchewan, Alberta, and British Columbia.

1921–22		1922–23	
Gals.	Value	Gals.	Value
168,057,671	$13,111,167	167,705,479	$11,998,088

feasible, requires no emphasis. Petroleum has become a fundamental necessity in the industrial and military life of a nation. Fuel oil is necessary for a navy, a mercantile marine, and for large industrial plants. Lubricating oil is essential for all machinery.

At present Canada depends largely on the United States for her supplies of petroleum products. Yet in the United States, with a production of crude petroleum during 1923 of 725,702,000 barrels, the public, the Government, and the oil companies already appreciate the gravity of the situation that will result when the domestic supply becomes so depleted as to fail to meet demands. Those that look beyond periods of temporary over-production, realize that the problem of furnishing sufficient oil to meet the inevitable and rapidly increasing demands is indeed of prime importance.

It is evident that the production of petroleum from Alberta bituminous sand is a question that should be given careful consideration. Such a production would apparently be relatively free from certain well recognized hazards that attach to the present production of well petroleum. Among these may be mentioned the uncertainty of locating oil pools, the uncertainty respecting amortization, the fluctuating price hazard due largely to uncertainty of uniform production, and the danger of new discoveries more advantageously situated with respect to markets.

PROCESSES FOR RECOVERY OF HYDROCARBONS

In this short paper it is impossible to describe in detail the various attempts that have been made to recover the hydrocarbon content from bituminous sand. The writer's investigation has included a determination of the relative efficiency of chemical solvents, and of various petroleum distillates; separation of bitumen by heated water at temperatures up to 320° F.; separation by flotation methods, and final purification of partly refined bitumen, by means of filter presses and centrifuging. The possible use of crude bituminous sand as fuel and the value of spent sand as a basis for the manufacture of glass have also been considered. Distillation of the crude bituminous sand has also been attempted, and crude petroleum recovered in this manner has been fractioned and the various fractions refined by the use of sulphuric acid and aluminium chloride. The results of this work are as yet inconclusive.

In the following summarized statement reference is made to the work of certain companies and individuals, in connection with the development of processes for the recovery of hydrocarbons from bituminous sand. At the plant of the Uvalde Asphalt Company, Texas, bituminous limestone was treated. The dates given indicate the approximate period during which experimental work or actual production has been carried on. This summary furnishes an interesting comment on the interest that has been aroused in the above problem.

Alcatraz Asphalt Company, Sisquoc, Cal., 1896-99.

Bituminous sand was passed through a series of large, steel crushing rolls and then into large, revolving, steel, jacketted heating drums. As the sand became softened by heat, it was met by an inflow of petroleum distillate (50° Bé.), and when thoroughly saturated, passed into other revolving

drums which acted as agitators. The bitumen in solution was then piped to the refinery at the sea coast, about 25 miles distant. There the solvent was recovered, and piped back to the separation plant, while the residual bitumen, 99 per cent pure, was led to storage. It is said that cost of mining was approximately 25 cents per ton, and that total cost of refined product varied from $11.30 to $14 per ton.

The above plant was designed by Mr. A. F. L. Bell, San Francisco, Cal., and erected at a reported cost of $1,000,000. It represented the largest attempt at commercial recovery of bitumen from bituminous sand by the use of a solvent. The work was abandoned about 1899.

Alcatraz Asphalt Company, Carpinteria, Cal. U.S. Patent 505416, 1891-97.

Primary disintegration was effected by passing the bituminous sand through revolving, steam heated bar grizzlies, partly submerged in heated water. The material was then passed through a series of steam-jacketted tanks, filled with heated water, and equipped with simple mechanical devices for removing bitumen and sand tailings. It is stated that sand tailings were approximately 98 per cent clean, and that bitumen recovered was 80-85 per cent pure. Final removal of remaining water and silt was effected by settling.

The above plant was designed by Mr. A. F. L. Bell of San Francisco, and represented a reported financial outlay of approximately $350,000. The capacity was approximately 108 tons of bituminous sand per 24 hours, with a recovery of approximately 15 tons refined bitumen. This plant probably represents the most successful achievement in connection with the recovery of bitumen from bituminous sand by water separation.

American-Canadian Oil Products Co., 530 Spreckles Building, San Diego, Cal., 1923.

Early in 1923, Mr. M. J. McClave, Director, Western Research Laboratories, Denver, Colo., conducted a series of experiments in Denver, in order to demonstrate the efficiency of water flotation when applied to treatment of bituminous sand. A novel feature of the McClave process consists in introducing into the water a small percentage of bentonite and sodium silicate.

In conducting experiments, on a laboratory scale, water in which $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent bentonite had been disintegrated, was used as a solvent. This bentonite—sodium silicate aqueous mixture, at a temperature of approximately 120° F., rapidly disintegrated all fragments of bituminous sand, and the resulting pulp was fed into a small pug mill heated to 200° F. In this mill, partial separation was effected, but the greater part of the pulp was further treated in a small two-compartment flotation cell. From this cell clean spent sand was removed by an elevator, and a mastic product, consisting of a large percentage of water and air, approximately 20 per cent fine mineral aggregate, and bitumen, was recovered.

During the summer of 1923, a sum of $12,500 was expended in construction and operation of a semi-commercial plant with a capacity of 25 tons per 24 hours, near San Luis Obispo, Cal. This plant was operated for a period of 30 days. Its essential features comprised a pug mill, flotation cells, settling tank and topping still.

Preliminary separation was effected in the pug mill and flotation cells and the product then passed to a large settling tank fitted with steam coils. In this tank the greater part of the water settled out and was drawn off, thus reducing the volume of product to about 25 per cent of its original bulk. Heat was again applied, all remaining air and water removed, a large part of the mineral aggregate settled out, and the final product passed to a topping still.

American Mineral Wax Co., Woodford, Okla., (about 1909).

Mr. A. Snyder, New York City, N.Y. (Supt. E. F. Riser, Woodford, Okla.). Separation of bitumen from hard bituminous sandstone was effected in a series of 4 tanks partly filled with heated water. All tanks were partly jacketted and were fitted with banks of steam coils. Smaller banks of steam coils were installed at points provided for discharges of bitumen, and steam jets at core valves provided for discharge of leached sand.

In the first tank partial disintegration was effected by a simple mechanical device, and complete disintegration in the second. The third and fourth tanks provided quiet water zones, where settling was effected. In the first two tanks, partly or fully leached sand was propelled by screw conveyers, and the separated bitumen on rising to the surface of the water was removed by mechanical skimmers. It is said that the capacity of this plant was approximately 2½ tons refined bitumen per 10 hours, and that the plant was the most successful separation unit operated in Oklahoma.

Armstrong, H. H., Pacific Finance Building, Los Angeles, Cal.; Can. Pats. 561171, 647566, 650242, 1923-24.

Ash, H. W., Cambridge, Mass.; U.S. Patents 757387, 779198, 1903-05.

The principal features of this process include a vertical cylindrical metal retort above a heating furnace, together with a blower, and a condenser. A number of horizontal perforated metal trays are provided in the retort, and on these the charge rests. Heated gases from the furnace pass through an annular space provided in the brickwork about the retort, and thence to a blower or fan. They then descend through a vertical flue in the centre of the retort, and rise through a perforated metal plate to the bituminous material undergoing distillation.

Information available indicates that demonstration of the above process was not carried beyond small scale experimental work.

Athabaska Petroleum Products, Ltd., 502 Union Trust Building, Winnipeg, Man., 1923. (Owners of N. S. Clark patents and processes.)

Part disintegration of bituminous sand is effected under pressure in a vertical, steam-jacketted tank, where it is acted on by superheated steam and by hydrocarbon gases. The partly disintegrated material passes by controlled discharge to a series of one or more separation tanks, partly filled with heated water, where complete disintegration is effected by the action of a series of vertically arranged rotary sprays. Oil vapours are withdrawn through outlets in the upper part of the chamber, and liquid hydrocarbons at a point near water level. It is claimed that the apparatus is of simple construction and automatic in operation.

Gavin, M. J., and *Bowie, C. P.;* U.S. Bureau of Mines, 506 Custom House, San Francisco, Cal., Can. Pat. 202622, 1922.

This process was designed primarily to overcome the difficulties involved in the commercial distillation of well petroleum containing a percentage of water, sand, and silt. It is proposed to incorporate with the original petroleum, additional inert material, in varying amounts up to 60 per cent, such as coal, peat, crushed shale, sand or diatomaceous earth. The resulting mixture is then placed on the hearth of a specially designed distillation chamber, where it is gradually impelled by means of rabbling blades, and under gradually increasing temperatures, to a discharge near the outer periphery of the hearth. Oil vapours are removed and condensed, while spent sand or other inert material is discharged continuously through sealed "gophers."

In 1922 an experimental retort was erected in San Francisco, by Messrs. Gavin and Bowie, of the U. S. Bureau of Mines, and between May 25 and July 29, a number of trial runs were conducted. The results obtained were encouraging but, in some respects, inconclusive. Probable costs of commercial operation cannot be deduced from data available at the present time.

The retort referred to above is the property of the U.S. Bureau of Mines, and at the present time (May, 1924) is available for experimental work in connection with distillation of bituminous sand.

California Oil Mining Corporation, Baltimore, Md., 1923.

In 1923 the above corporation undertook the erection of a commercial unit near San Luis Obispo, Cal., designed for the recovery of hydrocarbons from bituminous sand. The capacity of the plant is estimated at 500 tons per 24 hours.

Crude bituminous sand is fed into a disintegrator and equipped with two heavy screw conveyers, 18 inches in diameter, partly filled with hot water and a small percentage of petroleum distillate. Pulp from the disintegrator passes to a Cottrell vibrating screen, to remove pebbles and oversize lumps, and is then discharged into a second mixer where further distillate is added and complete disintegration is effected. The pulp is then passed through K. and K. flotation cells, and 60 per cent of the sand content is dropped. The concentrate containing about 40 per cent sand, is passed to a heating tank, then to an agitation tank, then to a specially designed horizontal retort, and finally to a Southwestern Engineering Company condenser, where desired cuts are made.

It is said that the plant referred to above represents an investment of upwards of $75,000. In November, 1923, construction was nearing completion, but actual operation has not commenced.

Clark, K. A., University of Alberta, Edmonton, Alberta, 1922-24.*

Following a comprehensive preliminary investigation on a laboratory scale, a semi-commercial plant was installed at the University of Alberta in the spring of 1923. It is stated that approximately 85 tons of bituminous sand was successfully treated by this plant.

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*The Press Bulletin, Department of Extension, University of Alberta, No. 11, Vol. IX, May 924. Third Annual Report of the Scientific and Industrial Research Council of Alberta 1922

Bituminous sand is first treated with heated water, containing a small percentage of silicate of soda. The pulp then passes through a series of mixing boxes and separation boxes, the latter providing quiet water zones where separation of sand and bitumen is effected. Partly refined bitumen overflows and is collected, while sand tailings are removed by a simple mechanical device. A complete statement dealing with the above investigation is being prepared by Dr. K. A. Clark.

Continental Asphalt Co., Ardmore, Okla., 1910.

About 1910 a small separation plant was erected at a point near Ardmore at a cost of approximately $25,000. Separation was effected by means of heated water, the bituminous sand being passed through a series of tanks providing agitation and quiet water zones. It appears that results were discouraging and the work was soon abandoned.

Coogan, Jesse; Jesse Coogan Engineering Company, Salt Lake City, Utah, Canadian Patent 207590, 1922-23.

The Coogan process for recovery of hydrocarbons associated with bituminous sands, embodies two stages of treatment. During the first stage, petroleum distillate is mixed with the crude bituminous sand. This softens the material, and to some extent breaks down the bond between mineral aggregate and associated bitumen.

As a second stage the partly digested product passes to a receptacle filled with heated water, and is there propelled through a specially designed inclined perforated cylinder. Mechanical devices are provided for discharging spent sand, and for removing liberated bitumen and oil from the surface of the water.

Cook, W. H., New Orleans, La.; U.S. Patent 652594, 1900.

This process is designed for the treatment of fluid or non-fluid substances, by centrifuging in a horizontal rotating cylinder. A filtering medium is provided, as well as mechanical devices for introducing fresh material and for removing waste.

Cooper, A. S., San Francisco, Cal.; U.S. Patents 507885 (1893) and 617226 (1899).

Bituminous sand is disintegrated at low temperatures, in a mechanically agitated drum, from which it is discharged into a second heated drum where it is thoroughly mixed with crude petroleum. This mixture is discharged into a third tank, where it is heated with a solvent (light petroleum distillate). The product from this tank, consisting of bitumen, crude petroleum and solvent, flows to a settling tank and thence to a distillation chamber. Here the lighter fractions are removed while the heavy bitumen is drawn off.

Downard, Jas. S., Dallas, Texas, 1903.

A small hot water separation plant was erected about 1903 near Ardmore, Okla., with a capacity of $4\frac{1}{2}$ tons refined bitumen per 10 hours. Treatment by agitators and in settling tanks of 11 per cent bitumen sandstone produced a bitumen 80 per cent pure at a cost of approximately $15 per ton.

Diver Extraction Process.

During 1920, an attempt was made at Fort McMurray to distill, in situ, the bitumen associated with the bituminous sand. A bore was sunk to the top of the bituminous sand stratum and cased. The bore was then continued, with a somewhat decreased diameter, into the bituminous sand itself. At the bottom of the bore a fireclay heater was provided. Gas was led from the surface, and ignited within the fireclay heater. Heat thus developed caused a limited volatilization of bitumen in the immediate vicinity, and oil vapours thus generated were led to a condenser at the surface. This effort appears to be of historical rather than of commercial interest.

Draper Manufacturing Co., Petrolia, Ont.; Canadian Patent 230423, 1922-23.

This process is designed for distillation of bituminous sand, with recovery of liquid, semi-solid or solid hydrocarbons. Distillation is effected in a revolving horizontal cylindrical drum, mounted on trunnions and heated from below. The drum is provided with openings for charging and discharging, and with agitating devices to prevent coking on the inner surface. Oil vapours are withdrawn to a condenser through a hollow trunnion. A small unit was installed by the Draper Manufacturing Company in 1922 near Waterways, Alberta, and operated intermittently during 1922 and 1923.

Dutcher, C. E., 3919 California St., San Diego, Cal.

In 1921, Mr. C. E. Dutcher erected on Hangingstone creek, near McMurray, a small rectangular distillation retort. The outer shell consisted of a rectangular metal box, provided with a firebox, stack and heavy hinged door. An inner, and somewhat smaller rectangular metal box constituted the actual distillation chamber, and was provided with an offtake for oil vapours. Charges of bituminous sand were trammed on small metal trucks into the distillation chamber, and combustion gases from the firebox, circulating through the space between inner and outer shells, developed a temperature sufficient to cause distillation of bitumen associated with the sand.

This retort is of historical rather than commercial importance, since it represents the first attempt at distillation of bituminous sand in the McMurray district.

Fenton, J. T., P.O. Box 34, Salt Lake City, Utah. Canadian Patent 212908; U.S. Patents 1394481, 1396173, 1396174, 1409388, 1424998, 1432170, 1920-23.

The Fenton process was designed primarily for distillation of coals. The inventor considers that, with certain modifications, it can be adapted to the distillation of oil shales and bituminous sand.

The apparatus consists of a vertical, cylindrical retorting chamber, provided with suitable charging and discharging devices. The oil vapour line is designed as an expansion zone condenser system, equipped with float controlled choke valve outlet traps, and leads to water cooled condenser. Expansion stages may be modified as desired.

Distillation is effected through the medium of steam, superheated to 750° to 800° F., and under 10 to 20 pounds pressure. Distillation products are removed from the retort immediately they are formed, and formation of heavy hydrocarbons is prevented.

Operation of retorts is intermittent. Heat recovery is effected by arranging retorts in units of three. Normal steam is passed through a retort in which distillation has just been completed, and thence to preheat material in a newly charged retort.

A very complete experimental unit, designed primarily for the distillation of coals, and having a charged capacity of one ton per charge has been erected in Salt Lake City. It is said that the sum of approximately $12,000 has been expended in developing and demonstrating the Fenton process.

Ferromastic Mining Company, Woodford, Okla., 1911-13.

Hard bituminous sandstone, carrying 10-12 per cent bitumen, was treated in a series of four jacketted tanks, filled with heated water at a temperature of approximately 212° F. In the first tank agitation and disintegration was effected, separation being completed subsequently in quiet water zones. Mechanical devices for removing bitumen and sand tailings were provided. The nominal capacity of the plant was 3½ tons refined bitumen per 10 hours. Wages costs ranged from $1.75 to $2 per 10-hour day, and the cost of producing refined bitumen, 97 per cent pure, was from $11.50 to $14 per ton.

Frasch, H. A. (Uvalde Asphalt Co., Cline, Texas). U.S. Patent 581546, 1892-96.

In 1893 the Litho-Carbon Company undertook to develop a process for the treatment of bituminous limestone carrying 12-15 per cent bitumen, near Cline, the plant and property being later acquired by the Uvalde Asphalt Company. In a plant designed by the late Mr. H. A. Frasch, separation of bitumen was effected by means of naphtha circulating through a series of steam jacketted tanks, 14 to 16 feet high, and 6 feet in diameter. Condensed solvent vapours were circulated continuously through the system, the bitumen being recovered as a residuum from the solvent-bitumen solution. It is said that the capacity of 16 tanks was 100 tons of rock per 24 hours, and that the working force at the plant consisted of 8 men. The loss of solvent was less than 2 per cent, while the cost of refined bitumen produced was $14.50 per ton. Operations at Cline were discontinued prior to 1900.

Fyleman, Ernest, Ph. D., 103 Cannon St., London, E.C. 4, England. (Eng. Pat. 163519; Can. Pat. 203676).

The principle involved consists in washing the sand with a cold, dilute aqueous solution of low surface tension. "A solution which froths readily, such as an alkali soap, of the alkali salt of a weak organic acid, or of saponin. Any of these solutions actually effects the desired result; in the case of a liquid mineral oil, the change takes place in the cold; where a semi-solid bitumen is present, it is necessary to render it sufficiently fluid either by warming or by adding a small quantity of a solvent such as petroleum oil."

In a contribution to the Society of Chemical Industry, Jan. 31, 1922, Vol. XLI, No. 2, pp. 14T-16T, Dr. Fyleman outlines the theory and estimated cost of treatment.

Georgeson Extraction Process, Calgary, Alberta, 1923-24.

The Georgeson Process depends on introducing steam or heated water through pipes and separating, in situ, hydrocarbons associated with the bituminous sand.

In 1923 and 1924 boiler and other necessary equipment were installed on Hangingstone river and on Horse river (tp. 89, range 9, W. of 4th), near McMurray, Alberta. It is stated by those in charge of the above work that results of the preliminary tests were satisfactory. The method used appears to be a modification of the Frasch Sulphur Process which has been successfully applied in Texas, U.S.A.

Ginet, J. H., 720 Symes Building, Denver, Colorado; Canadian Patent 222951, 1923.

A single commercial unit of a Ginet retort, consists essentially of a horizontal metal cylinder, 3 feet in diameter and 20 feet in length. A series of "scoops," attached by arms to a shaft passing through the retort, agitate the charged material and propel it to a point of discharge. The heating furnace is of special design.

It is claimed that distillation conditions within the retort are favourable to high recovery of hydrocarbons, and that flexibility of operation and adjustment permit of distillation of various types of oil shales and oil sands.

In 1923, a single Ginet unit of commercial size was erected near De Beque, Colorado.

Hartley, Carney, 720 Colorado Building, Denver, Col., 1919-22.

During 1919, Mr. Carney Hartley and associates erected in Rio Blanco Co., Colo., a small retorting unit designed for the recovery of hydrocarbons from oil shales and bituminous sand. Owing to difficulties in connection with titles to mineral leases, and to other causes, this work was discontinued, and a second plant erected in Routt county, Colo. The first trial run was made on December 1, 1919, and the plant was further perfected during 1920-21. Pending completion of further experimental work, the probable commercial value of the process cannot be definitely asserted.

Distillation is effected in an enclosed vertical metal tube, 24 inches in diameter, which is equipped with a rotating conveyer device for regulating movement of charge through retort. Oil vapours are removed to condensers through multiple offtake pipes. It is claimed that advantages of the system are heating efficiency, simplicity of construction, and a minimum of working parts.

It is stated that experimental work has represented an expenditure of approximately $45,000.

Leonard, Geo. I., 1232 Marquette Building, Chicago, Ill., 1921.

Lindsay, Major General W. B., 9 Bank of Montreal, 64 Wall St., New York City, N.Y.

The process is based upon the direct application of a heating medium to the substance to be treated, and the selective fractional condensation of the resultant vapours. It is a continuous process, and automatic in its action.

In connection with the investigation of the above process, it is stated that research and experimental work have involved an expenditure of more than $400,000. It is considered by those in charge of the investigation, that the process is technically a success, and that the perfection of mechanical apparatus will permit of its commercial application.

Navin, Frank, Salt Lake City, Utah. Patent 197465. 1922-23.

After preliminary crushing, bituminous sand passes to a rotary mixer where it is acted on by some solvent,—such as a petroleum distillate,—and water at atmosphere temperature. It is claimed that the action of the rotary mixer results in a thorough commingling of the bitumen, solvent and water. The contents of the rotary mixer then pass to a settling chamber, where mineral matter and liquids settle according to their specific gravities. So far as the writer is aware, the demonstration of the process has not progressed beyond small scale laboratory work.

Parker, J. E., Denver, Colo., 1922-23.

In 1922 a small unit was constructed in Denver, Colo., in order to demonstrate the operation of the Parker process. It is said that the experimental work represented an outlay of upwards of $50,000.

The process is mechanical, and consists of agitation of bituminous sand in heated water. Mechanical means are provided for removing spent sand and separated oils or bitumen.

The apparatus consists of a circular steam-jacketted tank, 12 feet in diameter and 6 feet deep, with a centrally arranged annular compartment 3 feet in diameter and 6 feet deep. The tank is mounted on rollers and revolves at the rate of 30 to 60 r. p. m. A series of specially designed centrifugal agitators (mounted on a stationary frame) is provided in one quadrant of the tank. As the tank revolves, the disintegrated sand passes through a quiet water zone where it is removed by bucket elevator. Liberated bitumen is skimmed from the surface of the water and passes to dehydrator and storage.

The writer is advised that, owing to mechanical difficulties, the above process has been abandoned.

Philippi, J., New York City, N.Y.; U.S. Patent 655,416, 1900.

Bituminous sand is mechanically disintegrated in heated water. Devices are provided for removing the separated bitumen and the sand tailings.

Price, S. R. and *Cook, C. L.*, San Francisco, Cal., U.S. Patent 1190633, Canadian Patent 194319, 1914-16.

During the period 1914-16, Mr. J. R. Price, of the City Street Improvement Company, San Francisco, Cal., and Mr. C. L. Cook, Chief Chemist, of the District of San Francisco, erected a small experimental unit at Oakland, Cal. Bituminous sand was subjected to the action of water, heated under pressure to temperatures ranging from 220° F.-312° F. In 1916, 400 pounds of Alberta bituminous sand was passed through the plant. The product obtained had a purity of 94 per cent, and represented 78·7 per cent of total bitumen contained in original crude sand. It was considered that with certain modifications, much better results might have been secured, but the investigation was discontinued in September, 1916.

Pritchard, T. W., New York City, N.Y.

The research model designed for demonstration purposes consists essentially of an externally heated vertical, jacketted metal retort, having a charged capacity of approximately 15 pounds bituminous sand; a condenser; a centrifugal pump or blower, and a gas holder. A wire basket, of a somewhat smaller diameter than the retort, is provided as a container for the charge of bituminous sand.

In operation, gases from distillation of bituminous sand are forced by the blower through the retort and condenser. A part of the gases which are not condensed are returned through the pump to the retort. Excess gas passes to the gasometer, which serves as an equalizer.

Demonstrations of the research model referred to above were made at Ottawa and at Toronto in February, 1924.

Oil Exploitation Corporation, 100 Broadway, New York City, N.Y.

In 1922 the above corporation erected a demonstration plant near Taber, Cal., with a capacity of approximately 50 tons bituminous sand per 24 hours. Crude bituminous sand entered a steel tank, equipped with a heavily constructed cutting and mixing flight conveyer. Superheated steam at 700° F. was introduced and accelerated the rate of disintegration.

The disintegrated pulp flowed freely to a series of hot water flotation cells, where part separation was effected. The partly separated product then passed through a second set of similar cells for final treatment, while the partly leached sand tailings were dewatered by a drag belt, and passed through a settling compartment. The sand tailings, as finally removed, were free from bitumen.

The above plant was not in operation at the time of the writer's visit in November, 1923, but it is claimed by those in charge, that a bitumen, 99 per cent pure was produced. Mr. James McEvoy, of Toronto, Ont., reported on the process in December, 1922.

Simpson, Louis, 172 O'Connor St., Ottawa, Canada. Canadian Patent Nos. 234961, 235114, 1923.

Separation of bitumen from bituminous sand or other similar material, is effected by maceration in heated water. It is claimed that the apparatus, as designed, is efficient and that labour and other operating costs would be low.

Snyder Asphalt Co., Ardmore, Okla., 1906-08.

This company erected a small separation plant near Ardmore, Okla., about 1912. Material treated consisted of a rather hard bituminous sandstone carrying from 10 to 12 per cent bitumen. The rock was disintegrated and partial separation effected in a series of tanks filled with heated water. Actual operations were discontinued prior to 1913.

Smith, Emery E., 651 Howard St., San Francisco, Cal., 1923-24.

As a result of a very extensive investigation undertaken by Mr. Smith on behalf of a local syndicate, it is proposed to recover, as liquid hydrocarbons, a portion of the bitumen associated with bituminous sand. The residue would be utilized as paving material—notably in the manufacture of paving blocks of various dimensions. It is stated that upwards of $60,000 has been expended in connection with the investigation.

Southern Asphalt Co., Ardmore, Okla., 1906.

This Company operated a small hot water separation plant near Woodford, Okla., about 1906. Operations ceased many years ago.

Trumble, M. J. (Trumble Coal and Oil Shale Company), 1011 South Fremont Ave., Alhambra, Cal. Canadian Patent 235611, 236455, 237127, 237128, 237773.

The process comprises two essential features, namely, a series of disintegration tanks in which bituminous sand is acted on by a solvent (a petroleum distillate), and a tube furnace, in which the solvent together with bitumen leached from the bituminous sand is distilled.

Sand tailings from the disintegration tanks pass toward point of discharge through jacketted conveyers, and over banks of pipes carrying heated oil vapours. In this manner the solvent associated with sand tailings is distilled and recovered. The heated sand tailings then pass through a jacketted conveyer where their heat is transmitted to the solvent-bitumen mixture flowing toward the tube furnace. Fractions are removed as soon as they are formed.

It is claimed that complete heat recovery is a feature of the process. Gasoline and lubricating oils are the principal products, but other fractions can be made as required as well as residuum of any penetration.

Tait, Jas. D., 1125 11th Ave., W., Vancouver, B.C., Canadian Patent 237770.

This process consists in separation of bitumen from bituminous sand following disintegration in heated water. Bitumen and accompanying sand are floated to surface of water by means of a controlled current. The sand settles out and the film of bitumen is carried away by the current. It is claimed that bitumen with a specific gravity greater than $1 \cdot 0$, may be separated as readily as bitumen of lower gravity. Simple mechanical devices control feed of bituminous sand and circulation of heated water. So far as the writer is aware, this process has not been demonstrated on a scale sufficiently large to indicate its commercial possibilities.

Turner, C. Irlam, Manchester, England. Canadian Patent 194425.

This process was primarily designed for distillation of oil shales. The inventor considers, however, that it is also well adapted to the distillation of bituminous sands.

The plant consists of a superheater capable of delivering an adequate amount of superheated low pressure steam to the bottom of a vertical metal retort. The retort is provided with mechanical means for charging and discharging, and is continuous in action. An automatically controlled gas offtake valve is provided. The offtake valve being shut, the steam is forced upward and through the descending charge, which is heated gradually by it, under continuously increasing pressure to a temperature which varies throughout the retort, being lowest at the top and highest at the bottom. Increase in pressure raises the temperature, and at the same time tends to retard emission of vapours. When pressure has reached the desired maximum, the offtake valve automatically opens, pressure throughout the retort is at once reduced and is followed by an immediate drop in temperature throughout the retort, owing to escape of the steam and vapours to the condenser. Reduction of pressure permits of the formation and release of volatiles from all material possessing of the temperature necessary to bring about destructive distillation.

Tar Springs Refining Company, Tar Springs, Okla., 1902-03.

In 1902-03, a plant was erected for treatment by means of heated water, of soft bituminous sand carrying from 30-45 per cent bitumen. The crude sand was passed progressively through disintegrators, separators, accumulators and reducers. The separators were, in reality, spitzlutten provided with steam pipes, revolving screens, and devices for continuous discharge of sand tailings and of bitumen. In the accumulators, which were heated by steam coils, practically all water and a large part of the lighter oils were driven off. The asphalt remaining passed to the "reducers," where application of direct heat reduced the penetration to the point desired. It is said that production costs of asphalt varied from $12 to $15 per ton. In 1903, the Tar Springs plant was destroyed by fire caused by ignition of uncontrolled petroleum vapours.

Wurtz, H., Newark, N.J. U.S. Patent 821323., 1906.

The apparatus referred to in this patent consists essentially of heating furnace, distillation chamber and condenser. The distillation chamber or retort is provided with a series of trays on which the bituminous sand or other material is placed; while being charged, it is removed from its position within the furnace. The action is thus intermittent.

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